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# Criteria for Selecting RF Power Detectors

By Pierre Genest, Hubert Grandry, Hassan Chaoui
ON Semiconductor

**Here are the basics of power detector operation, along with the performance criteria to consider when selecting discrete or integrated power detectors**

The very first RF transmissions were immediately followed by the need for RF power measurement. The easiest (and earliest) method for measuring power is the well known peak detector, where a device—usually a diode—extracts the amplitude of the signal. In the case of amplitude modulation, the information of interest is directly accessible in the detected voltage, but when the measured parameter is the signal's power it has to be translated into a more useful form.

The diode detector has been dominant for decades and is still widely used. Recently, the development of high volume radio communication systems has justified the design of dedicated power detector integrated circuits ranging from temperature compensated diode detectors to complex logarithmic detectors. Choosing the right solution requires that the critical parameters are well identified.

## Power Detector Key Parameters

*Operating frequency:*

The RF signal frequency is probably the first parameter to consider when choosing a detector. The detector must be fast enough to extract the signal's amplitude. It must also provide a constant response over the desired frequency range. For example, a detector used to measure the transmitted power in a GSM mobile phone must exhibit the same sensitivity from 880 MHz to 915 MHz. Two internal parameters that are critical to achieve this requirement are the sensitivity (or gain) variation versus the frequency, and the input impedance matching. The ON Semiconductor NCS5002 is an excellent example of frequency response optimization (Figure 1). The input matching elements have been integrated in the device to guarantee a very low VSWR. The design is based on wideband structures to allow operation from 200 MHz up to 3 GHz. These two features ensure very low variation over the frequency range and simplify the design since no frequency compensation tables are necessary.

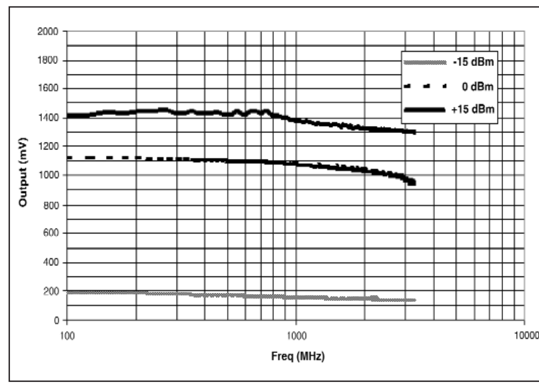


**Figure 1 · Frequency response of the NCS5002 RF power detector.**

*Sensitivity and linearity:*

Sensitivity is the detector's ability to return usable information from a very low input signal. So the sensitivity definition is strongly linked with the processing capability of the system. If the detected signal is processed by an ADC having 1 mV step, the designer will check that the minimum signal level he wants to detect actually gives more than 1 mV at detector's output. Higher sensitivity is better, but this cannot be achieved by

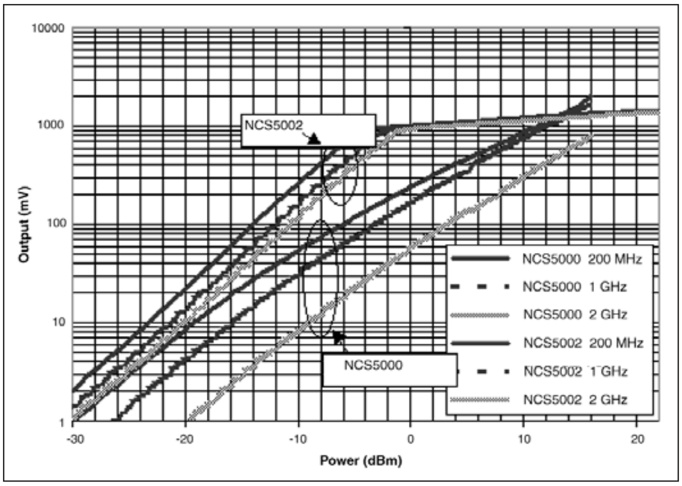


Figure 2 · Amplitude response of the NCS5000 (nonlinear) and NCS5002 (piece-wise linear) detectors.

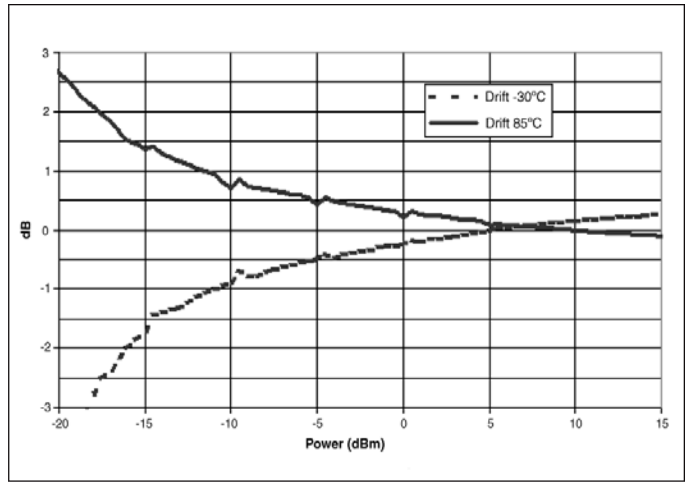


Figure 3 · NCS5000 detection accuracy vs. temperature for input power of –20 dBm to +15 dBm.

simply increasing gain. With high signal variations, the accuracy must be good for the maximum input signal, too. That's why detectors have been classified in two categories: linear and nonlinear. High linearity is required for a demodulator, or when the designer cannot calibrate the detection curve. The NCS5000 illustrates this type of device. Its compensated Schottky diode detector provides very high linearity (Figure 2). Because this is a unity gain device, with direct reading of detected voltage, the characteristic is very repeatable and no calibration is required.

When a wide detection range or high sensitivity are required, it is no longer possible to use a unity gain device. The detected signal must be amplified. The drawback is that amplification also applies to the maximum input signal, which may saturate the detector. A better solution is nonlinear amplification. The gain is maximum for minimum input level, and decreases when the detected signal becomes closer to the saturation voltage. Because the device is not linear, a minimum calibration is now necessary. Many nonlinear detectors are available on the market, from true logarithmic detectors made with expensive RF processes to piece-wise linear detectors, which represent a good compromise between dynamic range and complexity. The NCS5002 is a good illustration of piece-wise linear detector. The nonlinearity allows operation between –30 dBm to +20 dBm, and the calibration remains simple because the characteristic is split in two linear sections.

*Variations with environment:*

Once implemented in a system, the detector must provide reliable information independent of the environment conditions. The requirements on the power supply rejection or temperature variations fully depend on the system implementation. Integrated detectors usually have much higher power supply rejection performances than discrete solutions based on diodes. In fact, the detector is often supplied by a regulator. This provides even more protection towards power variations. The variations with temperature are more difficult to manage at system level, because accurate temperature measurement is seldom available. So the stability versus temperature entirely relies on the detector itself. Again, we find different behavior between unity gain detector and detector with amplification. Unity gain detectors such as the NCS5000, which is based on Schottky diodes, have higher intrinsic stability while non-linear detectors need more complex internal compensation structures to achieve equivalent performance. This is perfectly illustrated by the NCS5000 characteristics in Figure 3. The detection accuracy is expressed in dB as a function of the input power for two extreme temperatures. The reference is the detected level at ambient temperature.

*Ease of use:*

The ease of use is seldom mentioned as a critical parameter, but it can very significantly impact the development schedule. The discrete diode detector is simple, but its optimization versus frequency and temperature over the full input power range, can consume a lot of time when the requirements are close to the performance limits.

With an integrated detector, the optimization has been already done, and the function is fully characterized. The RF designer will probably confirm by his own measurements that the evaluation board gives the same results than the data sheet. He will then redo these measurement with the device in the application, and the work will be completed. The NCS5000 application schematic in Figure 4 shows how a GSM power

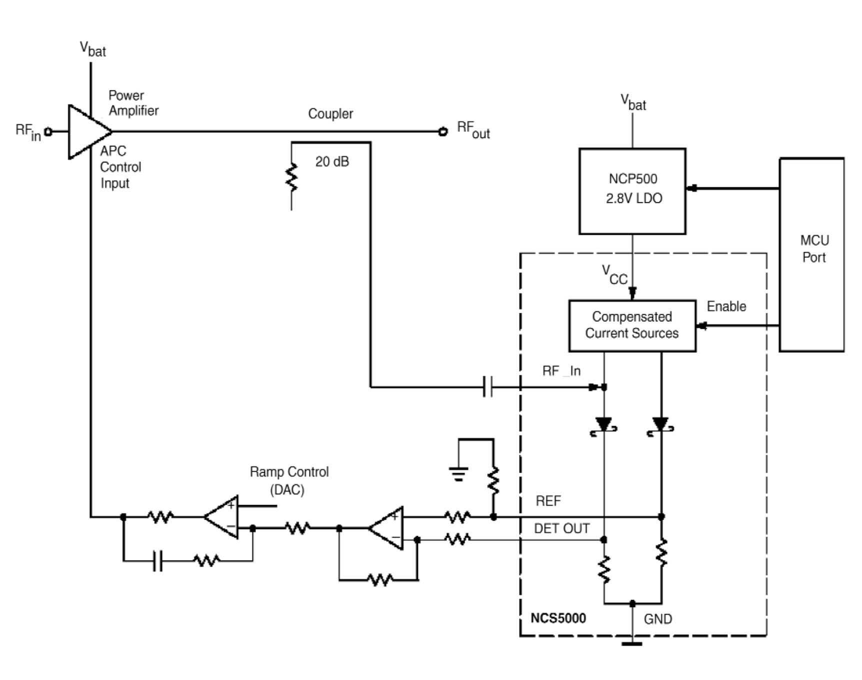


**Figure 4 · Typical application of the NCS5000 power detector in a GSM power amplifier.**

amplifier can be controlled with only one detector and two general purpose operational amplifiers.

## Conclusion

Integrated RF detectors are today widely available and tend to replace the classical diode detector each time higher sensitivity and stability are required. This broad choice of devices means that a power detection solution virtually exists for all applications. By giving a choice between linear and non-linear detection, the NCS5000 family covers the power detection requirements in the 200 MHz to 3 GHz frequency range and input power between –30 dBm and +20 dBm.

## Author Information


Pierre Genest, Hubert Grandry and Hassan Chaoui can be reached at ON Semiconductor, SCG France SAS, BP1112 - 14 Rue Paul Mesplé, 31035 Toulouse Cedex 1, France.